

The CARD Experiment:

Fluid Shifts, Vasodilatation and Ambulatory Blood Pressure Reduction during Long Duration Spaceflight

^{1,2}Peter Norsk, ^{2,3}Ali Asmar, ⁴Morten Damgaard and ⁵Niels Juel Christensen

¹USRA/NASA, Johnson Space Center, Houston, Texas, USA;

²Department of Biomedical Sciences, University of Copenhagen, Copenhagen, Denmark;

³Department of Clinical Physiology & Nuclear Medicine, Bispebjerg University Hospital, Copenhagen, Denmark;

⁴Department of Clinical Physiology & Nuclear Medicine, Koege Hospital, Koege, Denmark;

⁵Department of Internal Medicine and Endocrinology, Herlev University Hospital, Herlev, Denmark.





ISS026E012919

Paolo Nespoli
European Space Agency astronaut

Purpose

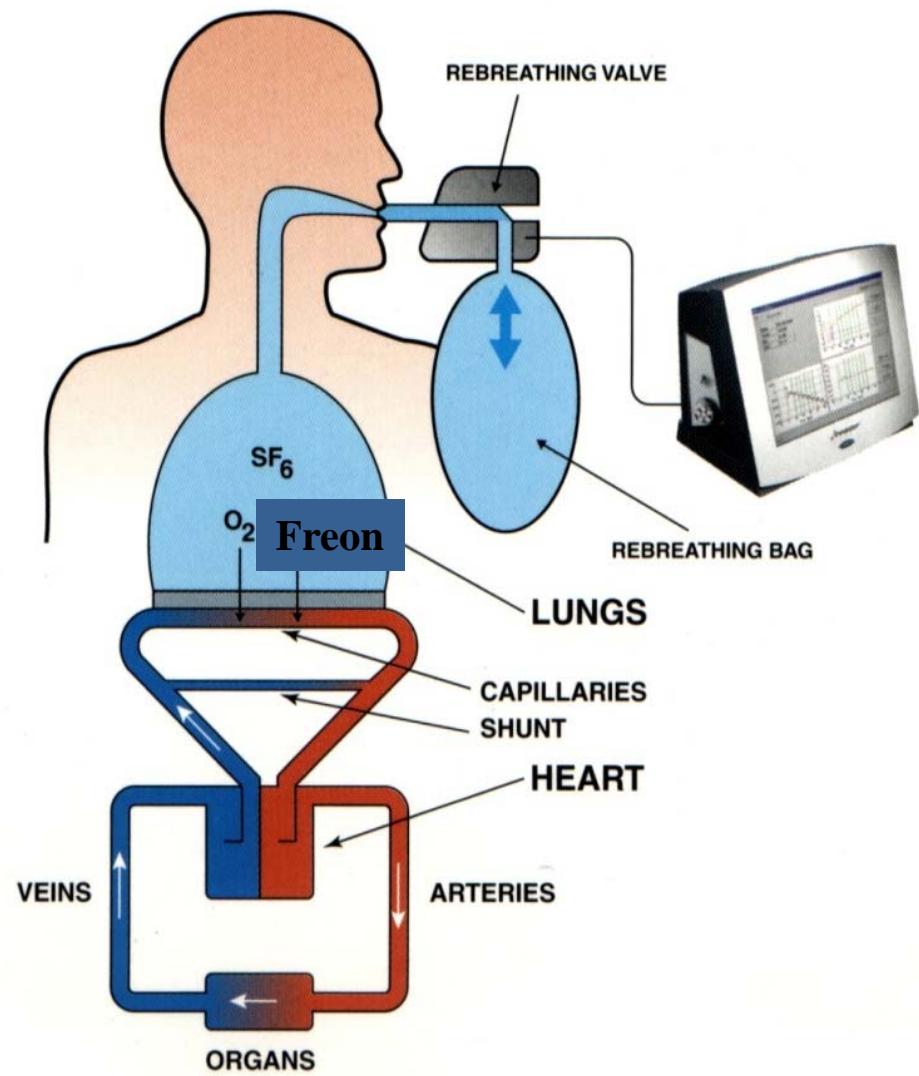
To investigate how fluid shifts, blood pressure and systemic vascular resistance adapt to long duration (3-6 months) spaceflight.

*Based on results from one week into a shuttle mission
(Norsk et al., Hypertension, 47: 69-73,2006)*



Cardiac Output (Rebreathing)





Cardiac output
by
rebreathing

Cardiac
Output
(Rebreathing)



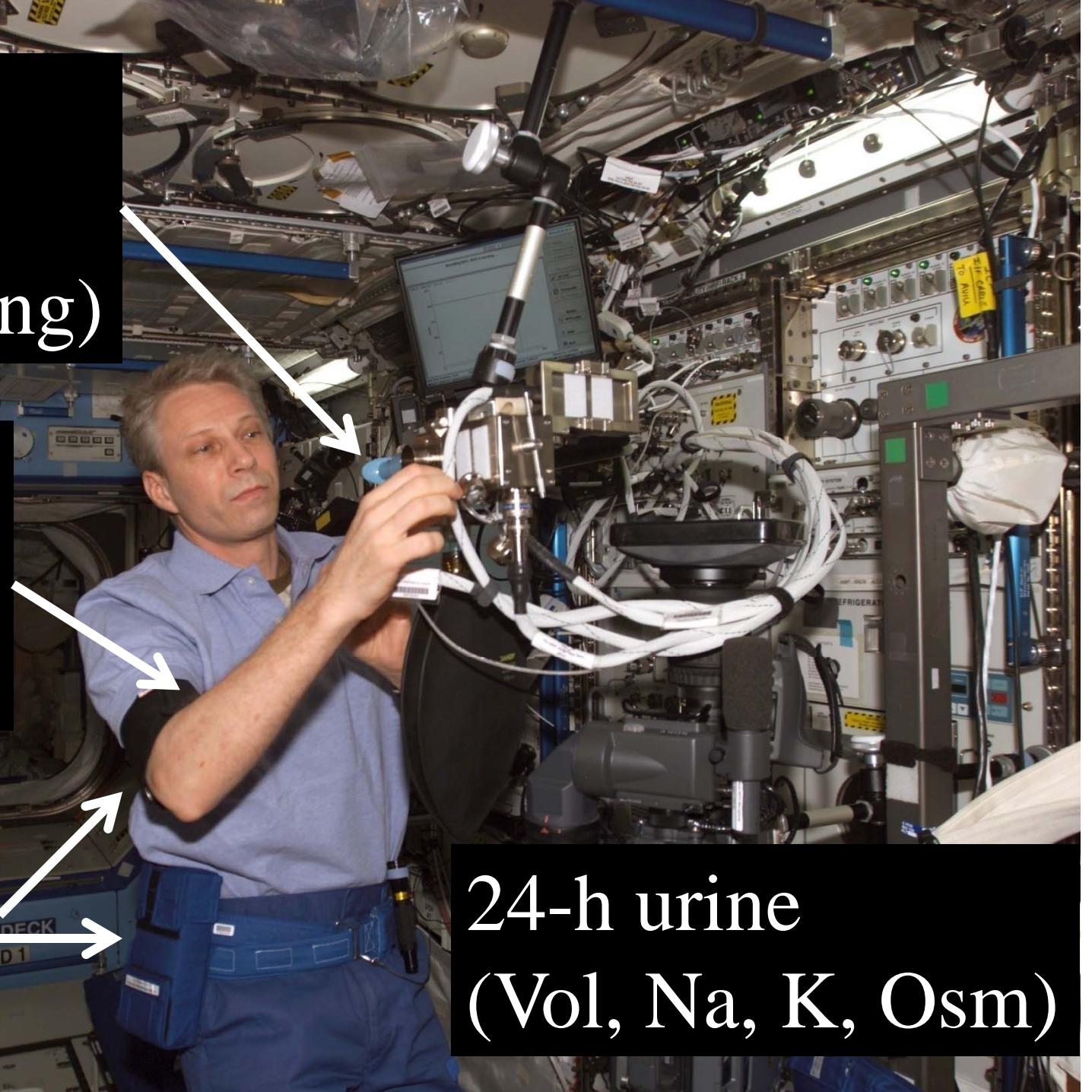
Blood
Pressure
(Brachial)

Cardiac
Output
(Rebreathing)

Blood
Sample
(Catechol)

Blood
Pressure
(Brachial)

24-h urine
(Vol, Na, K, Osm)



Experimental protocol

Pre-flight: Launch minus 322 – 71 days
In-flight: Launch plus 85 – 192 days in-flight
Post-flight: Landing plus 58 – 209 days

Time:	12:00	16:00	20:00	24:00	04:00	08:00	12:00
	14:00	18:00	22:00	02:00	06:00	10:00	

Blood pressure: X X X X X X X X X X X X X X X X X X
(Ambulatory)

Cardiac output: X X X X X X X X X X X X X X X X X X
(Seated)

Blood sampling: X
(Seated)

Urine collection: >-----<
(ambulatory)

X: Execution.

Experimental protocol

Pre-flight:	Launch minus 322 – 71 days
In-flight:	Launch plus 85 – 192 days in-flight
Post-flight:	Landing plus 58 – 209 days

Time: **12:00** **16:00** **20:00** **24:00** **04:00** **08:00** **12:00**
 14:00 **18:00** **22:00** **02:00** **06:00** **10:00**

X: Execution

Results

N = 8 males:

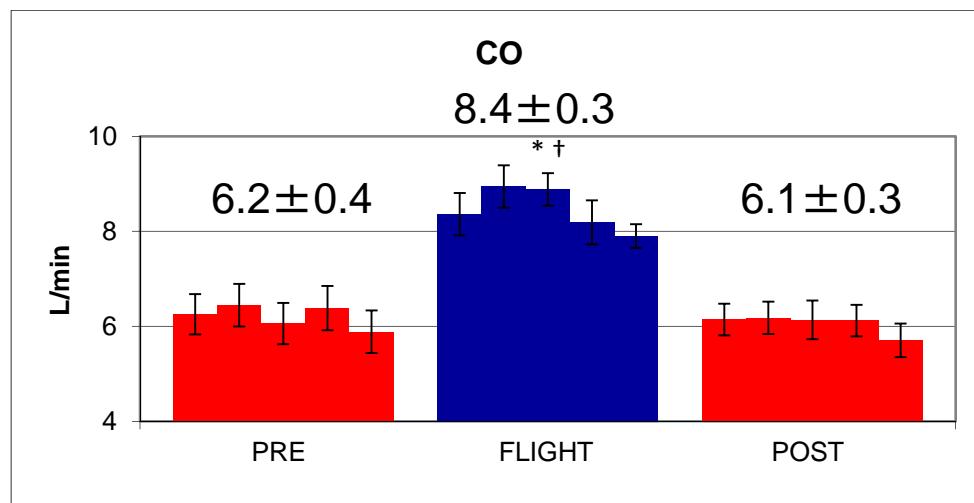
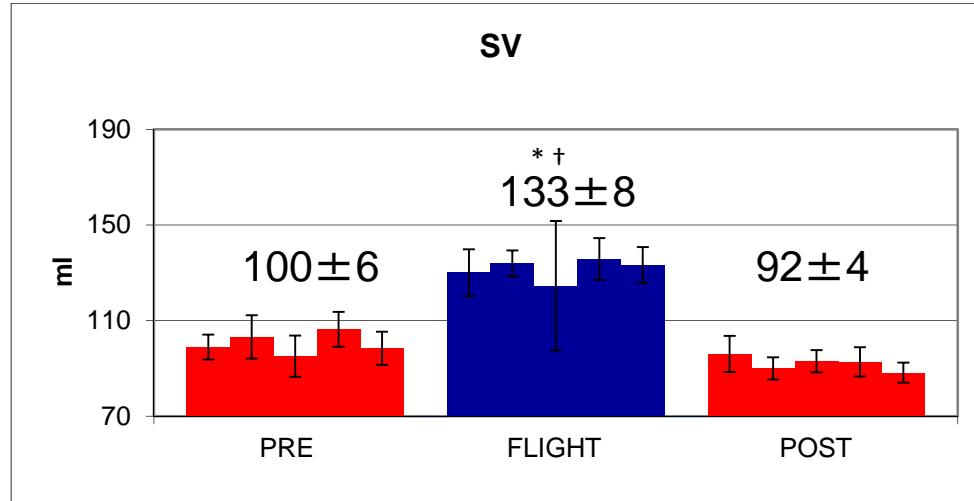
Age: 49 ± 1 y

Height: 181 ± 2 cm

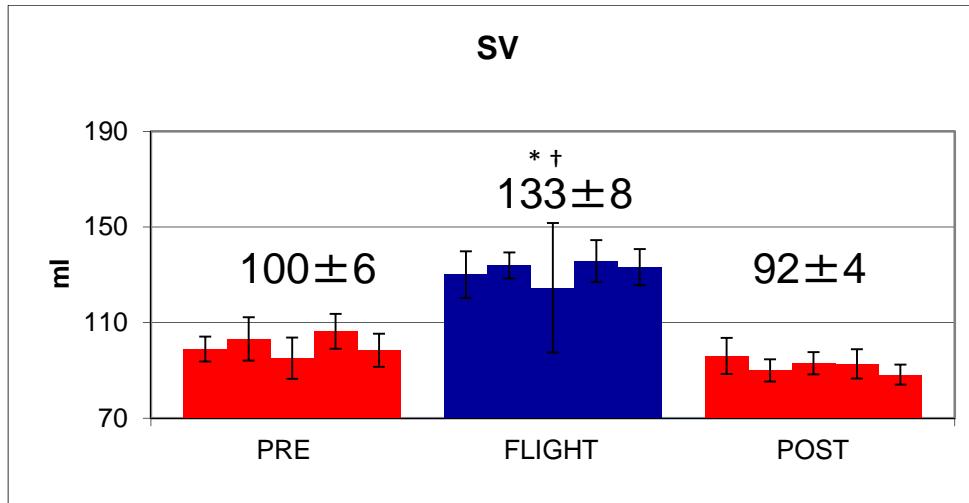
Weight: 85 ± 4 kg

Fluid Shifts

Stroke volume



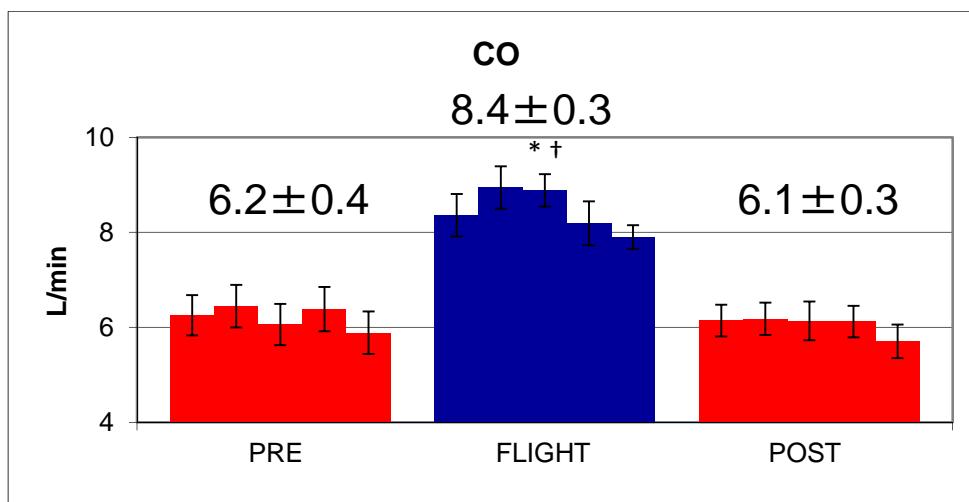
Cardiac output



Fluid Shifts

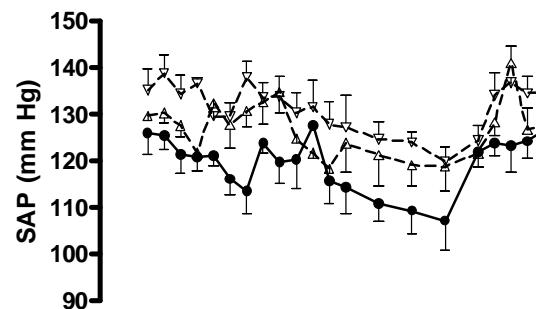
Stroke volume

35 ± 10% increase



Cardiac output

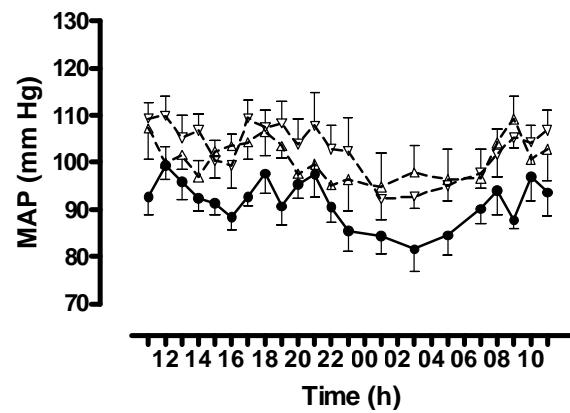
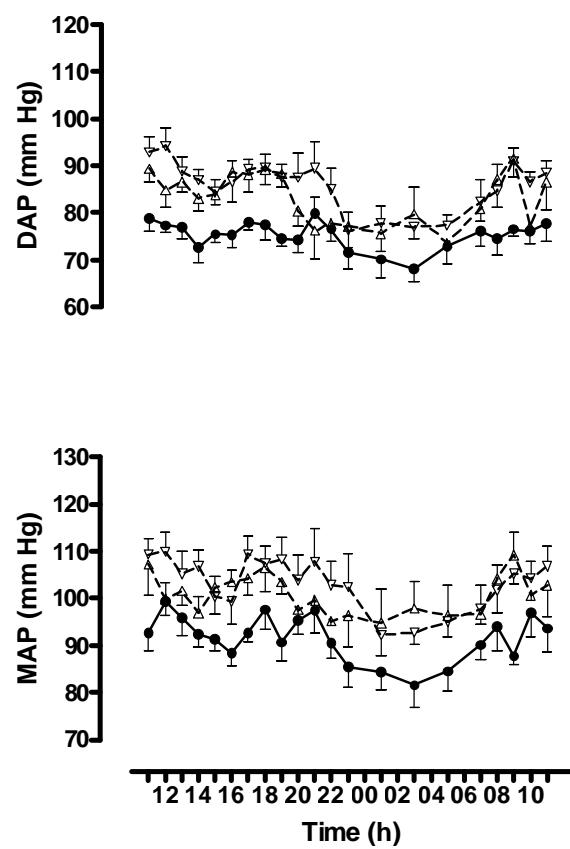
41 ± 9 % increase

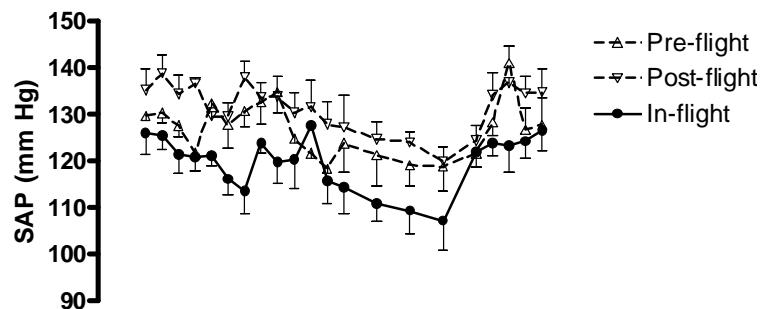


-△- Pre-flight
-▽- Post-flight
● In-flight

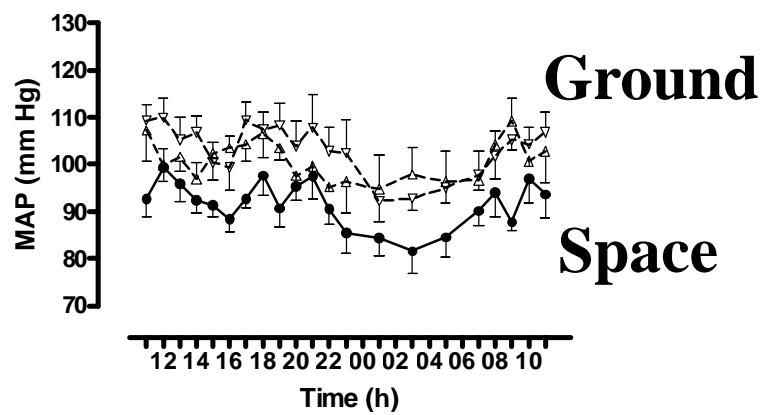
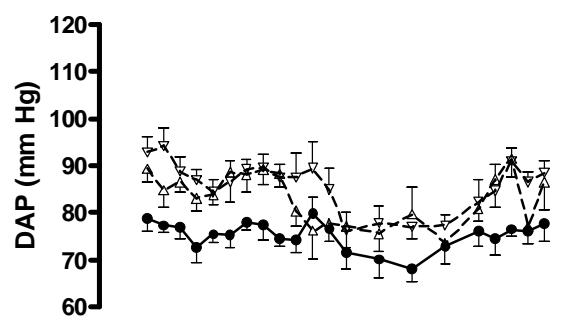
Blood Pressure

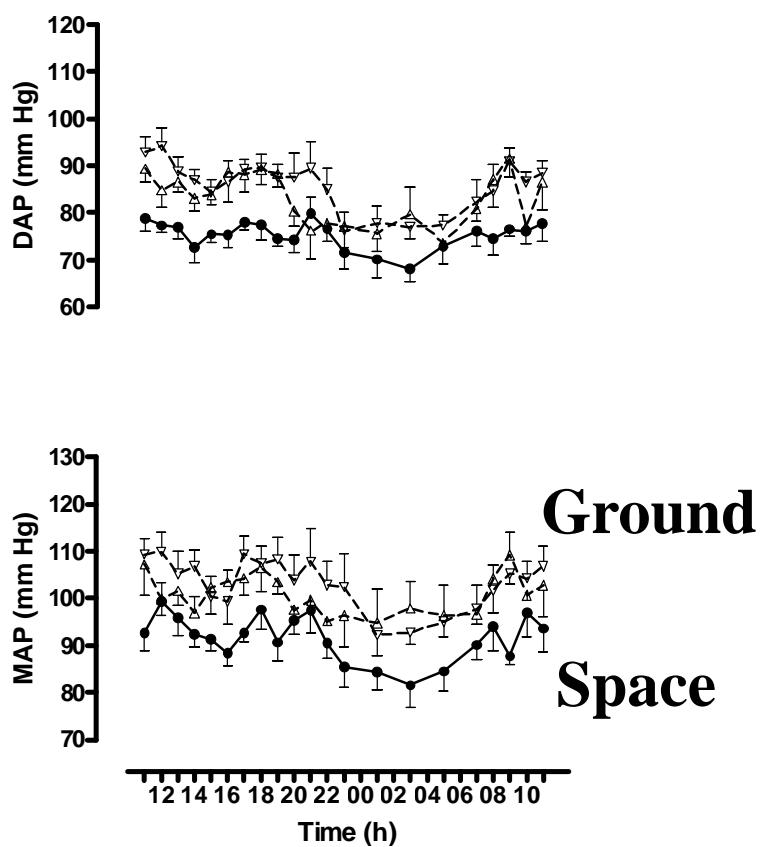
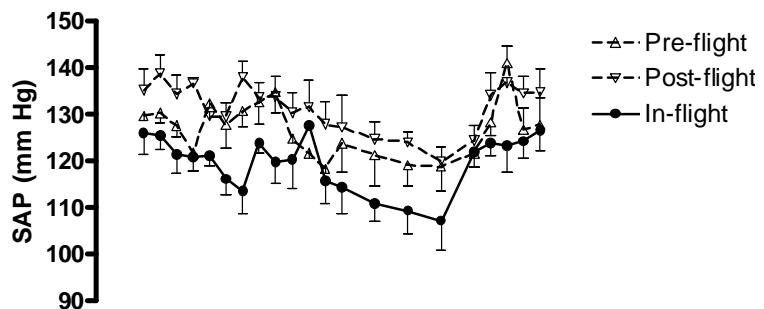
(24-h ambulatory brachial)





Blood Pressure (24-h ambulatory brachial)



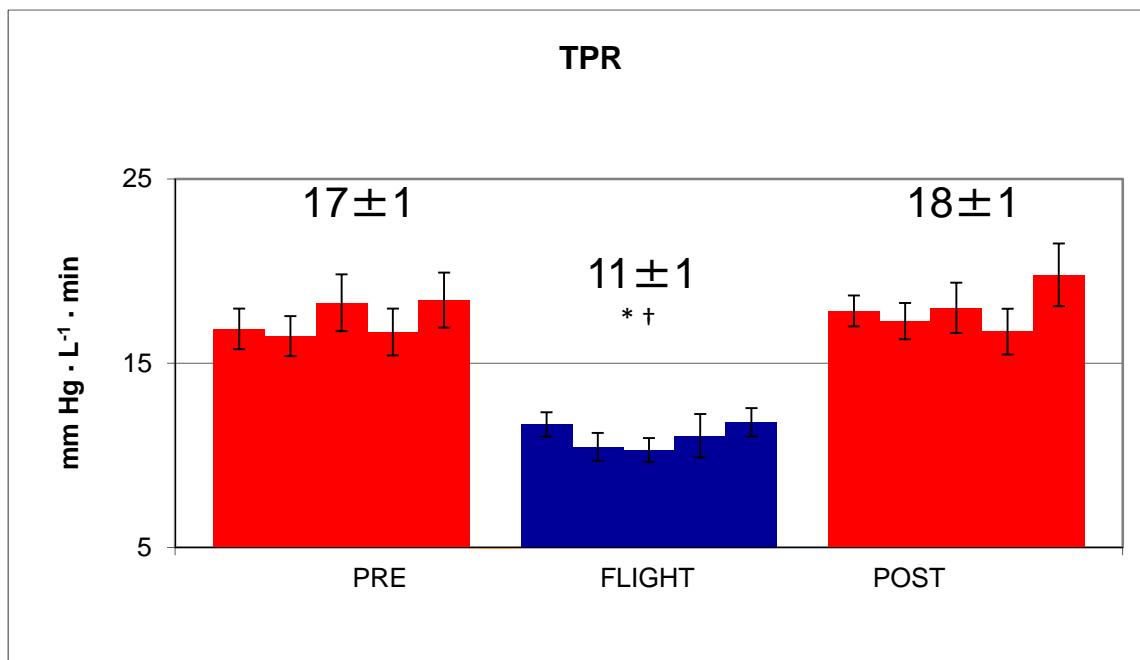


Blood Pressure (24-h ambulatory brachial)

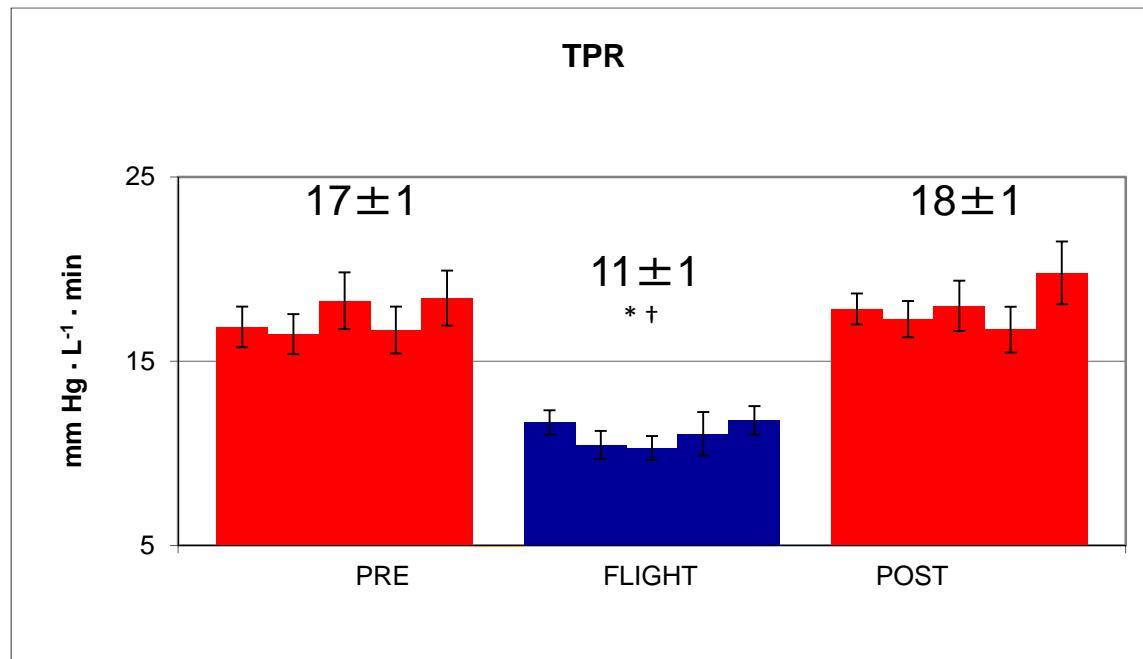
- 10 mm Hg decrease
- No change in heart rate
- Nightly dip maintained

Ground
Space

Systemic Vascular Resistance



Systemic Vascular Resistance



39 ± 4 % decrease

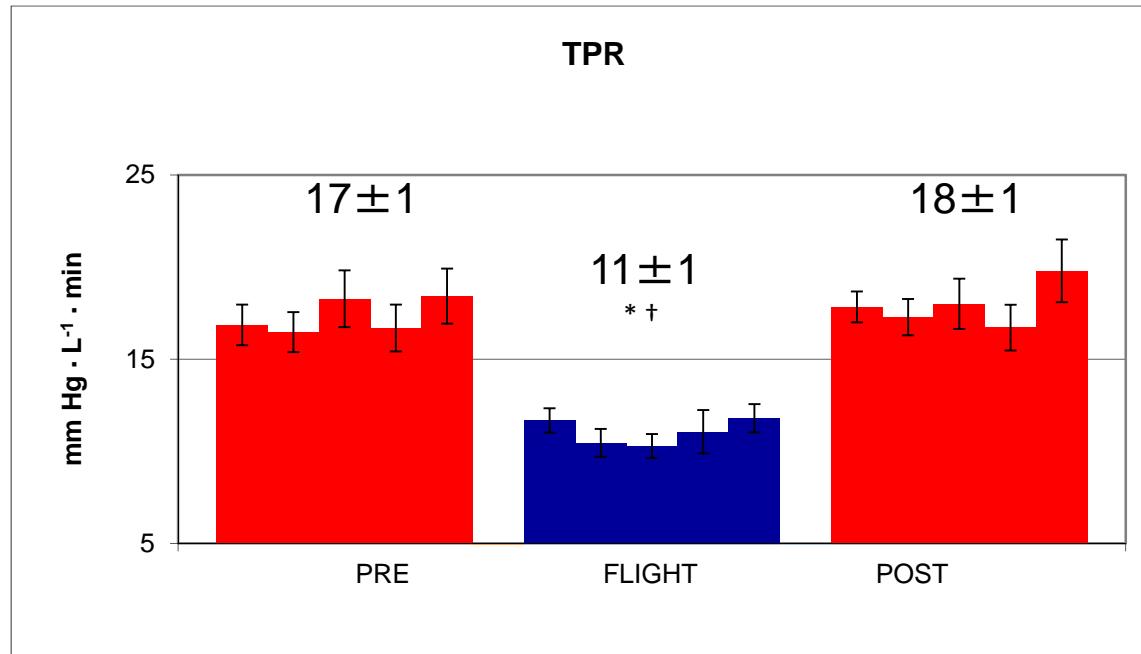
Systemic Vascular Resistance

Plasma noradrenaline (ng/l):

730 ± 130

720 ± 90

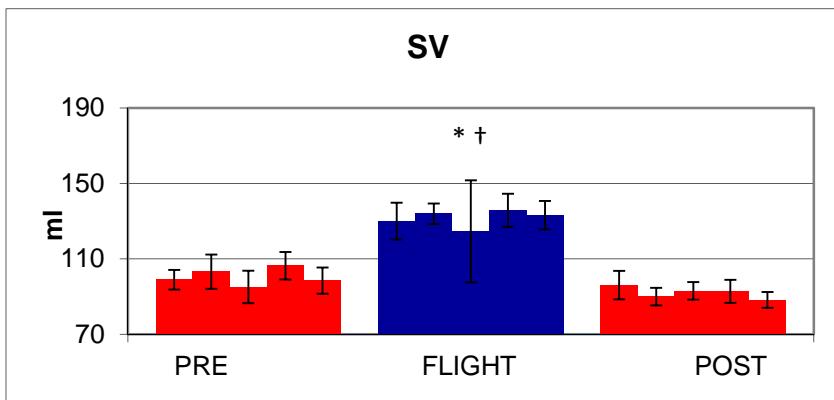
730 ± 100



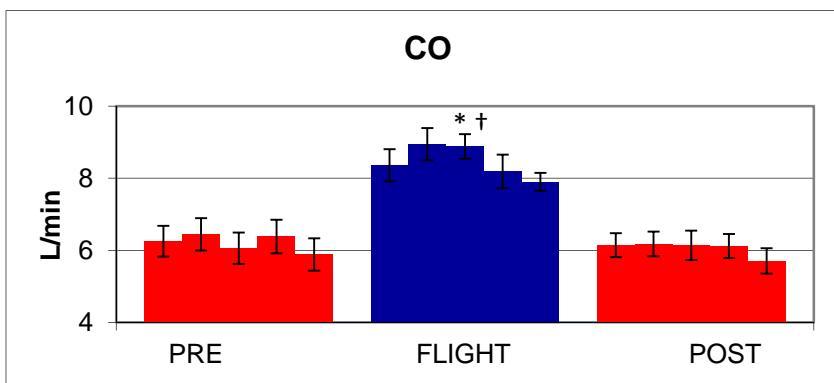
$39 \pm 4\%$ decrease

Future challenge (I):

To relate stroke volume and cardiac output to VIIP!



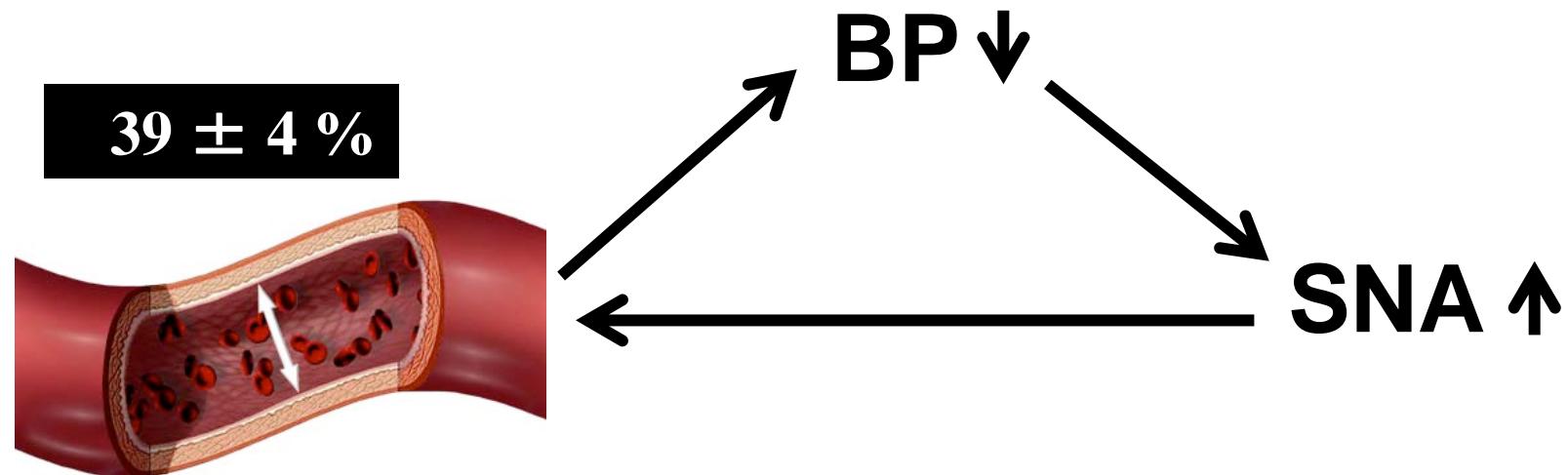
$$35 \pm 10$$



$$41 \pm 9$$

Future challenge (II):

To identify the spaceflight vasodilatation mechanism



Acknowledgements:

Co-authors

Niels J. Christensen (Herlev Univ. Hosp., Herlev, Denmark)
Ali Asmar (Bispebjerg Univ. Hosp., CPH, Denmark)
Morten Damgaard (Koege Hosp., Koege, Denmark).

Laboratory technical assistance

Jakob Utzon-Frank (Univ. CPH, Denmark)
Inge H. Petersen (Univ. CPH, Denmark)

ESA assistance

Poul Knudsen (Danish Aerospace Company, Odense, Denmark)
Thomas A. E. Andersen (Danish Aerospace Company, Odense, Denmark)

Allain Maillet (Cadmos, CNES, Toulouse France)
Stephanie Herr (Cadmos, CNES, Toulouse, France)

Simone Thomas (ESA-ESTEC)
Jennifer Ngo-Anh (ESA-ESTEC)
Patrik Sundblad (ESA-ESTEC)
Astronauts (ESA-EAC)

NASA assistance

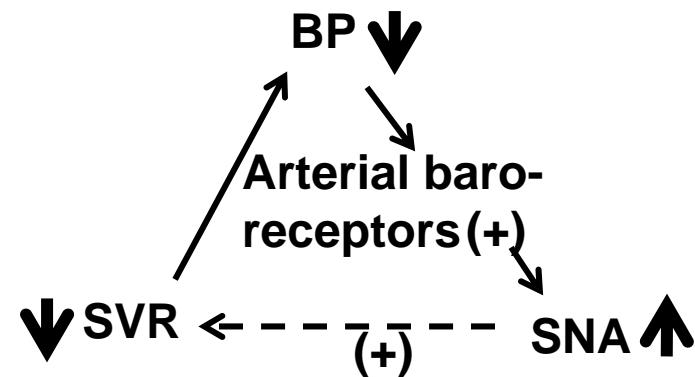
Suzanne McCollum and Kathleen McMonigal (NASA-JSC)
Astronauts (NASA-JSC)

Norsk et al. J. Physiol. 593: 573-584, 2015.

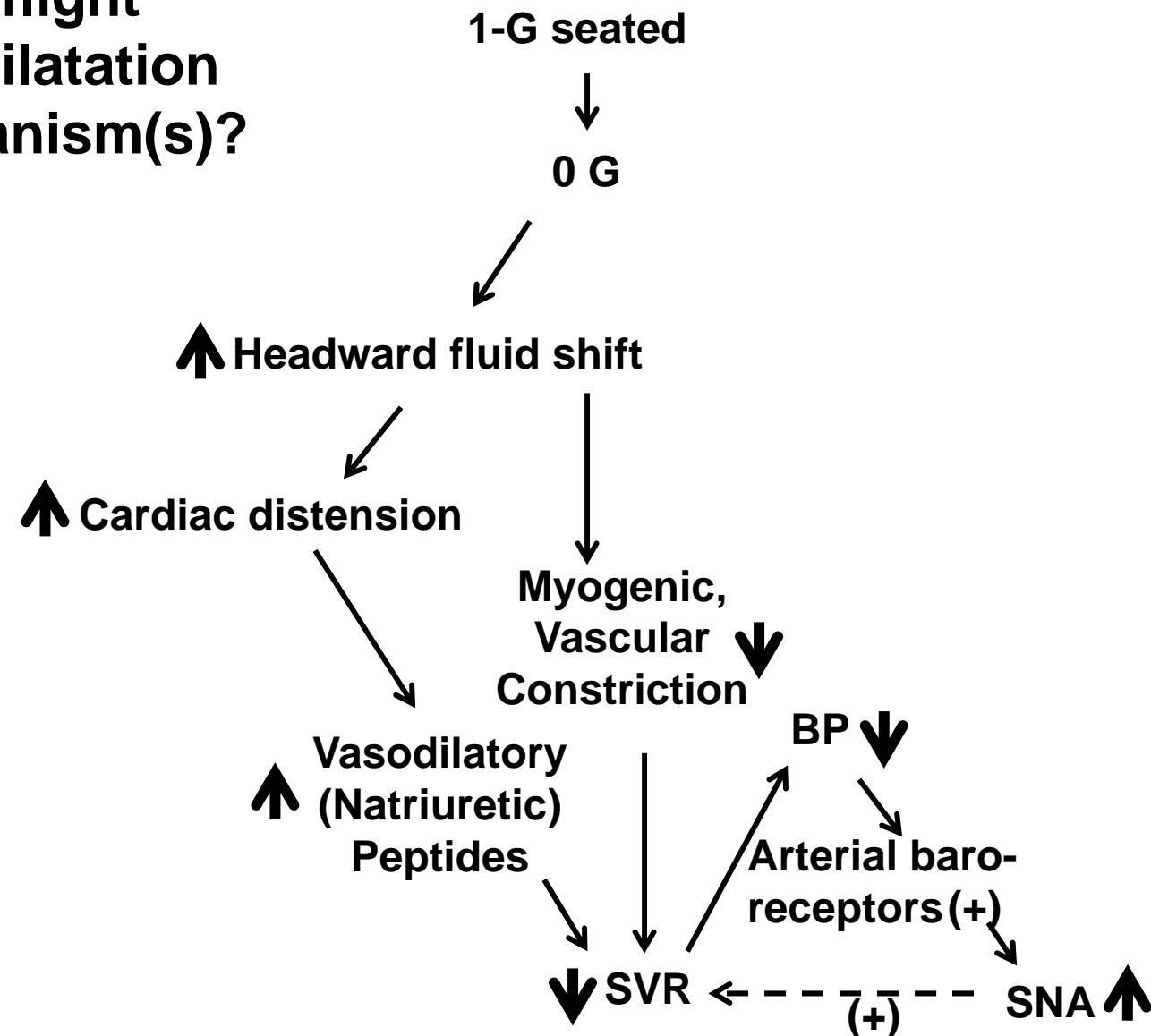
Thank you!



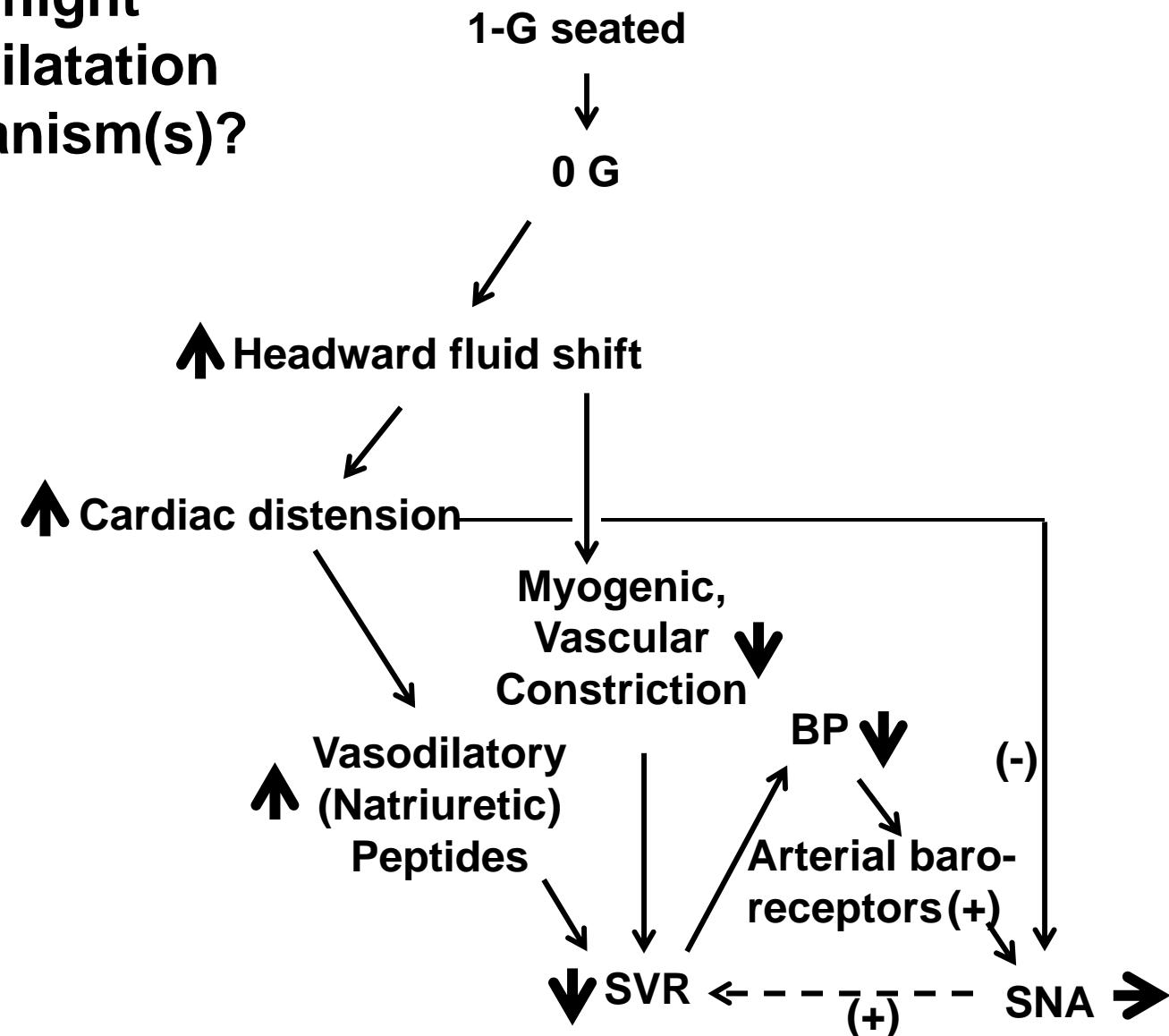
Spaceflight Vasodilatation Mechanism(s)?



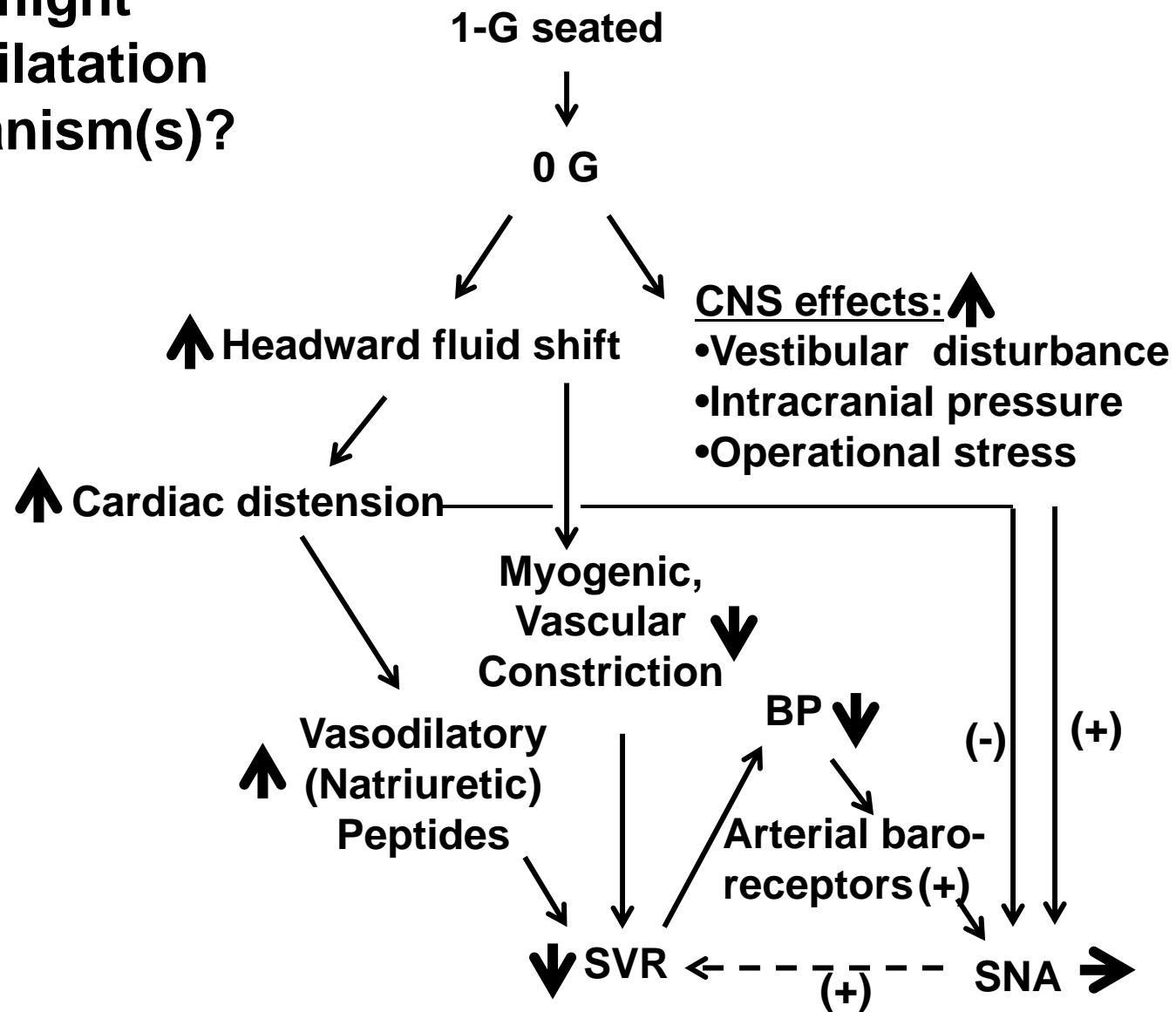
Spaceflight Vasodilatation Mechanism(s)?



Spaceflight Vasodilatation Mechanism(s)?



Spaceflight Vasodilatation Mechanism(s)?



Spaceflight Vasodilatation Mechanism(s)?

